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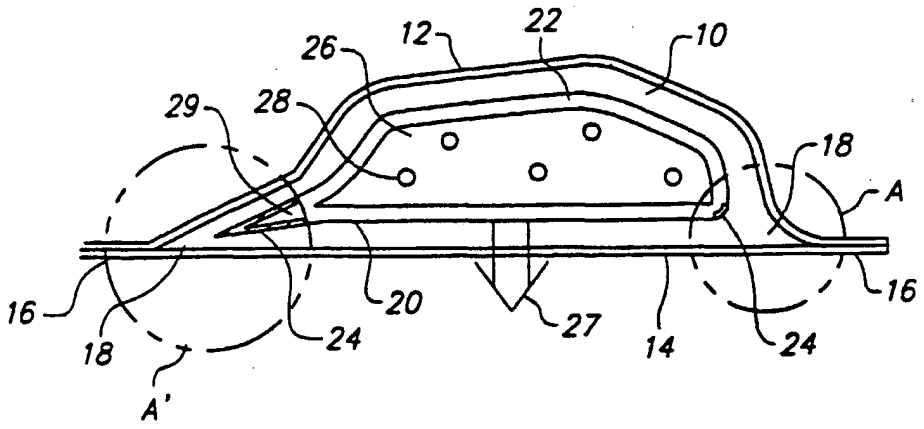
(54) Title: ARTICLE FOR SEALING A CAVITY WHOSE CROSS-SECTION INCLUDES AN ACUTE CORNER AND METHOD OF USING THE SAME



(57) Abstract: A sealing article (20) is disclosed, for sealing a cavity (10) whose cross-section includes at least one acute corner (such as created by pinch flanges (16)), such a cavity being exceptionally difficult to seal completely by a conventional foaming sealer due to the high viscosity of a foaming sealer. The sealing article includes a heat-foamable primary sealer (22), a secondary sealer (24) (for example, a hot melt adhesive or wax) disposed on a surface of the primary sealer, and a holder (26). When the sealing article is placed within the cavity, the holder positions the primary sealer such that the secondary sealer is located opposite an acute corner of the cavity. When heated to or above its foaming temperature, the primary sealer foams and drives the secondary sealer into the acute corner. Between the foaming of the sealer and the flow of the secondary sealer into the acute corner, the cavity is completely and effectively sealed.

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ARTICLE FOR SEALING A CAVITY WHOSE CROSS-SECTION INCLUDES AN ACUTE CORNER AND METHOD OF USING THE SAME

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention relates to sealing articles for cavities having acute corners or narrow crevices, and methods for making and using such sealing articles.

2. DESCRIPTION OF RELATED ART

Channels are commonly found in automobiles, boats, aircraft, other vehicles, structures (both land and marine), and the like. It is desirable to seal the cavities in such channels against the passage of gases such as air or fumes, moisture, fluids, particulates, etc. As the automotive industry is especially concerned about sealing cavities such as in pillars in the body structure of automobiles and similar vehicles, the present invention will be discussed primarily in this context.

During the fabrication of automobiles, many body components contain cavities that require sealing to prevent the ingress of moisture and contaminants that can cause corrosion of the body parts. This is especially true with unibody structures, where a heavy frame is replaced by a structurally designed space frame that inherently presents a number of moisture- and contaminant-collecting cavities. These cavities also serve as passages through which road and engine noise and other sounds may be transmitted during operation of the vehicle. For example, the A, B, and C pillars of a vehicle represent elongated cavities that can collect moisture and contaminants and can also transmit sounds that can then radiate into the passenger compartment unless the cavities are at least partially filled with a sealant material. There are other irregular cavities in a vehicle body that desirably are sealed to prevent moisture and contaminants from entering that area and being conveyed to other parts of the vehicle body.

A currently favored technique is the use of a heat-activated sealing foam material. Typically, a mass of a material capable of expansion (foaming) at elevated temperatures, i.e. a thermoplastic mixture containing both a heat-activated foaming agent and a heat-

activated crosslinking agent, is placed on a bracket or other mechanical support, usually made from sheet metal or a molded high temperature thermoplastic, that is capable of being mechanically fastened within the cavity. Because automobile bodies are now typically coated by total immersion in phosphating, rustproofing, electrocoating, and other paint baths to ensure that the interiors of all open cavities are coated, the sealing article (the bracket, together with the mass of foamable material), should not fill the cavity cross-section before foaming, so that the coatings may enter the cavity during immersion, flow around or through the sealing article, and drain from the cavity afterwards. As the automobile body is passed through an oven to cure the coating to the metal of the body, the foamable mass expands to fill the cavity cross-section and to seal against the walls of the cavity.

While this technique has proved generally satisfactory, a recurring problem area is the sealing of pinch flanges. A channel may be made from two pieces of stamped sheet metal that are welded along their mating flanges, causing the cross-section of the channel to have highly acute corners, forming a longitudinal narrow crevice where these pinch flanges are located. Most foamable sealing materials are based on crosslinked or crosslinkable compositions which are formulated to be highly viscous while being expanded to prevent sagging. But this same high viscosity renders them incapable of completely filling and sealing the acute corners of the pinch flanges in the cavities. Instead of penetrating the pinch flange's acute corner, the viscous foaming material follows the path of least resistance, flowing and expanding in the Z-direction (along the longitudinal axis of the channel, normally perpendicular to the sealing article), instead of into the pinch flange area. Consequently, the cavity may not be fully sealed. Even a small, pin-hole sized residual opening may allow the undesirable passage of gases, fumes, liquids, particulates, and sound. Further, when air is forced through the small opening, a whistle effect may actually create noise. Therefore, it is desirable to reliably and completely seal the cavity, including any acute corners therein.

BRIEF SUMMARY OF THE INVENTION

In a first aspect of the invention, there is provided a sealing article for sealing a cavity whose cross-section includes an acute corner, comprising

(a) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range;

(b) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a viscosity within the predetermined temperature range lower than that of the primary sealer; and

(c) a holder capable of holding the primary sealer in position within the cavity such that the secondary sealer is located opposite an acute corner of the cavity.

In a second aspect of the invention, there is provided a method of sealing a cavity whose cross-section includes an acute corner, comprising the steps of

(a) providing a sealing article comprising

(i) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range;

(ii) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a viscosity within the predetermined temperature range lower than that of the primary sealer; and

(iii) a holder;

(b) placing the cavity sealing article within a cavity whose cross-section includes an acute corner, the holder holding the primary sealer in position such that the secondary sealer is located opposite an acute corner of the cavity; and

(c) heating the primary sealer to within the predetermined temperature range to cause the primary sealer to foam and the secondary sealer to flow, the foaming of the primary sealer driving the secondary sealer into the acute corner opposite which the secondary sealer is located.

In third aspect of the invention there is provided, in combination,

(a) a cavity whose cross-section includes an acute corner and

(b) within the cavity, a sealing article comprising

(i) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range;

(ii) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a viscosity within the predetermined temperature range lower than that of the primary sealer; and

(iii) a holder which holds the primary sealer in position such that the secondary sealer is located opposite an acute corner of the cavity.

In a fourth aspect of the invention, there is provided a sealing article for sealing a cavity whose cross-section includes an acute corner, comprising

(a) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range, the foamable material comprising a base polymer having a melt flow rate of between 0.5 and 10;

(b) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a melt flow rate of between 25 and 200; and

(c) a holder capable of holding the primary sealer in position within the cavity such that the secondary sealer is located opposite an acute corner of the cavity.

In a fifth aspect of the invention, there is provided a method of sealing a cavity whose cross-section includes an acute corner, comprising the steps of

(a) providing a sealing article comprising

(i) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range, the foamable material comprising a base polymer having a melt flow rate of between 0.5 and 10;

(ii) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a melt flow rate of between 25 and 200; and

(iii) a holder;

(b) placing the cavity sealing article within a cavity whose cross-section includes an acute corner, the holder holding the primary sealer in position such that the secondary sealer is located opposite an acute corner of the cavity; and

(c) heating the primary sealer to within the predetermined temperature range to cause the primary sealer to foam and the secondary sealer to flow, the foaming of the primary sealer driving the secondary sealer into the acute corner opposite which the secondary sealer is located.

In sixth aspect of the invention there is provided, in combination,

(a) a cavity whose cross-section includes an acute corner and

(b) within the cavity, a sealing article comprising

(i) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range, the foamable material comprising a base polymer having a melt flow rate of between 0.5 and 10;

(ii) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a melt flow rate of between 25 and 200; and

(iii) a holder which holds the primary sealer in position such that the secondary sealer is located opposite an acute corner of the cavity.

BRIEF DESCRIPTION OF THE DRAWING(S)

Fig. 1 shows a cavity sealing article of this invention within a cavity to be sealed. Figs. 1a and 1b are enlarged views of the circled portions of Fig. 1.

Fig. 2 shows the sealing article of Fig. 1, after expansion to seal the cavity. Figs. 2a and 2b are enlarged view of the circled portions of Fig. 2.

Fig. 3 is an enlarged view of the sealing article of Fig. 1. Fig. 3a is a cross-section view of the sealing article of Fig. 3. Fig. 3b shows a variation of the invention.

Fig. 4 shows another embodiment of a sealing article of this invention. Fig. 4a is an enlarged view of the circled portion of Fig. 4.

Fig. 5 shows yet another embodiment of a sealing article of this invention, within a cavity to be sealed therewith. Fig. 5a shows the cavity after sealing.

Fig. 6a shows yet another embodiment of a cavity sealing article of this invention. Fig. 6b shows a sealing article of the type shown in Fig. 6a, placed within a cavity to be sealed therewith.

Figs. 7a, 7b, and 7c show various alternative arrangements of primary sealer and holder.

In this specification, numerals repeated from one figure to another denote the same or equivalent elements.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 is a cross-sectional view showing a first embodiment of a sealing article 20 emplaced at a predetermined location within a cavity 10, the longitudinal axis of which is perpendicular to the page. The axis of cavity 10 may be oriented in any direction: horizontal, oblique, or vertical; so that the cross-section that is to be sealed may be, correspondingly, vertical, oblique, or horizontal. Cavity 10 is defined by a pair of cavity wall forming members 12 and 14, which may be stamped metal sheets fastened together at pinch flanges 16 (e.g., by welding or riveting). Pinch flanges 16 cause cavity 10 to have in its cross-section acute corners 18 which are very difficult to seal completely using conventional foamable sealers.

Sealing article 20 comprises a heat-foamable primary sealer 22, second sealers 24, and a holder 26. Sealing article 20 is placed within cavity 10 with holder 26 holding primary sealer 22 in position such that secondary sealers 24 are located opposite respective acute corners 18, across a gap separating sealing article 20 and the walls of cavity 10. Preferably, sealing article 20 is placed within cavity 10 such that the plane of sealing article 20 is perpendicular to the longitudinal axis of cavity 10. In the embodiment shown, holder 26 further includes a barbed insert 27 which passes through an opening in the wall of cavity 10 and locks in place. Thus, primary sealer 22 is securely held in a predetermined position. Preferably, primary sealer 22 is held such that there is a gap around substantially its entire perimeter, i.e., between primary sealer 22 and the walls of

cavity 10 — that is, prior to expansion, primary sealer 22 does not contact the walls of cavity 10. Typically, the gap between primary sealer 22 and the walls is between 2 and 10 mm, most typically about 5 mm. This way, coatings may flow through cavity 10 during immersion of an automobile frame into a coating bath, coat its walls, and drain from it after removal from the coating bath.

Fig. 1a is an enlargement of the portion of Fig. 1 highlighted by circle A, to show more clearly one of secondary sealers 24 and a respective acute corner 18. In this particular variant, secondary sealer 24 is radiused in shape. In comparison, Fig. 1b is an enlarged view of the portion of Fig. 1 highlighted by circle A', in which secondary sealer 24 is pointed in shape, its tip generally aimed at the center of acute corner 18. A pointed shape may result in more effective flow of secondary sealer into acute corner 18, but is not essential for the practice of this invention. Further, secondary sealer 24 is shown in Fig. 1b as disposed on an optional elevation 29 of the surface of primary sealer 22, helping bring secondary sealer 24 closer to its respective acute corner 18. It is to be understood that sealing article 20 has been depicted with two differently shaped secondary sealers 24 as a matter of convenience of illustration and that a sealing article 20 may comprise one, two, or more secondary sealers 24 and that, where plural secondary sealers 24 are present they may have all the same shape, all different shapes, or some combination therebetween. It is to be further understood that secondary sealer 24 is not limited to the pointed and radiused shapes shown here, which are merely illustrative, but that other shapes, such as planar, are too permissible. Lastly, it is to be understood that optional elevation 29 need not be associated exclusively with a secondary sealer 24 having a pointed shape, but may be associated with secondary sealers 24 having other shapes.

When primary sealer 22 is heated to within a predetermined temperature range — that is, an activation temperature at which it foams — it expands with two effects: it seals most of cavity 10, adhering to the walls thereof wherever contact is made, and it drives molten secondary sealers 24 into respective acute corners 18. Possessing a lower melt viscosity than foaming primary sealer 22, secondary sealers 24 flow into and fill the narrow crevices of acute corners 18 better than primary sealer 22 could have. Between the

sealing actions of primary and secondary sealers 22 and 24, cavity 10 is completely and reliably sealed, including its acute corners 18.

Fig. 2 shows cavity 10 and sealing article 20 after heating and foaming, with cavity 10 now being sealed by primary and secondary sealers 22 and 24, which have expanded and/or flowed into sealing contact therewith. Fig. 2a is an enlargement of the portion of Fig. 2 highlighted by circle B, showing how secondary sealer 24 has filled in and sealed an acute corner 18. Fig. 2b is a corresponding enlargement of the part of Fig. 2 highlighted by circle B'.

Fig. 3 is an enlarged plan view of the sealing article 20 of Fig. 1. Fig. 3a is a cross-section view of the same, taken along line a-a'. Fig. 3b is an enlargement of the portion of Fig. 3 highlighted by circle C.

In a preferred embodiment, secondary sealer 24 is exclusively located only opposite acute corners 18. However, it is to be understood that this invention does not preclude the presence of secondary sealer 24 elsewhere on primary sealer 22. For example, secondary sealer may perimetrically surround primary sealer 22, as shown in Fig. 3b. Or, as a matter of manufacturing convenience, it may be desirable to apply secondary sealer 24 by dip-coating, with the result that secondary sealer substantially entirely surrounds primary sealer 22.

Typically, secondary sealer 24 is about 1 mm thick. Secondary sealer 24 may be deposited on primary sealer 22 by injection molding, being held in place thereafter by adhesive forces. Fig. 4 shows an alternative embodiment of the invention, in which one of secondary sealers 24 is held in place on the surface of primary sealer 22 other than by adhesive bonding. Rather, a capturing notch 30 in primary sealer 22 holds the secondary sealer 24 in place via an interference fit. Fig. 4a is an enlarged view of the portion of Fig. 4 highlighted by circle C. Other retention methods, such as insert molding, snap-ons, plastic nails or rivets, heat staking and plastic staples, may also be used.

Fig. 4 also shows another optional feature of a sealing article of this invention. Holder 26 may have an opening 35 therein, to further facilitate the draining of coatings after immersion in a coating bath. Opening 35 is partially filled by primary sealer 22, so that, upon expansion of primary sealer 22, opening 35 is closed thereby. It is to be

understood that the feature of opening 35 is not exclusively associated with the embodiment of Fig. 4, but can be used in combination with other embodiments of this invention. Where present, opening 35 may be singular or plural in number and may have a variety of shapes, the same or different. Opening 35 also may be used as a conduit for the passage of elongate objects such as wire bundles, drain hoses, and the like along the longitudinal axis of the cavity even after sealing, with expanded primary sealer 22 forming a seal therearound. Where the elongate objects also include narrow crevices, a secondary sealer 24 optionally may be used to seal around them.

In another embodiment of the invention shown in cross-section in Fig. 5, sealing article 20 further comprises a driver 36 comprising a crosslinked foamable polymer. Primary sealer 22, which in this embodiment will comprise an uncrosslinked foamable polymer, is in intimate contact with driver 36 and substantially surrounds driver 36 in the plane of sealing article 20. Further, in the spirit of illustrative variation, holder 26 is depicted not as a substantially planar molded bracket as shown in the previous figures, but as a stud. On activation of sealing article 20 by the application of a sufficient temperature for a sufficient time, driver 36 foams to expand and force sealer 22, which also foams and expands, into contact with the cavity walls. In turn, second sealer 24 melts or softens and is driven into and seals acute corners 18. Fig. 5b shows cavity 10 sealed by sealing article 20. The making and using of a driver/sealer combination is further described in the copending, commonly assigned applications of Chang et al., Serial no. 08/925,422, filed Sep. 8, 1997, and Serial no. 09/028,122, filed Feb. 23, 1998.

Fig. 6a shows, in a partial cutaway perspective view, yet another embodiment, in which holder 26 and primary sealer 22 are not in a face-to-face relationship, but rather in a nested relationship, with primary sealer 22 perimetrically surrounding a planar holder 26. An optional driver 36, disposed between primary sealer 22 and holder 36, is also shown. Fig. 6b shows a sealing article of the general type of Fig. 6a positioned inside a cavity 10 to be sealed therewith. In this depiction, holder 26 is of a two-piece construction, with a screw 37 joining the planar portion and the insert 27 portion thereof. This embodiment is further discussed in Takabatake, US 5,642,914 (1997) and

copending, commonly assigned application of Cydzik et al., Serial no. 09/013,400, filed Jan. 26, 1998.

Referring back to previous figures, holder 26 may have through-holes 28 passing across its thickness, as shown in the plan views of Figs. 1, 2, 3, and 4 and in the cross-sectional view of Fig. 3a. Primary sealer 22 may be co-molded with holder 26. During the molding process some of the material of primary sealer 22 flows through through-holes 28, securely interlocking the two components together. Fig. 3a shows how through-holes 28 may be chamfered to provide a more effective interlocking of primary sealer 22 and holder 26. Variations within the spirit of this invention include those in which through-holes 28 are straight-walled, those in which through-holes 28 are replaced by recesses (not shown) which may be either chamfered or straight-walled, and those in which neither through-holes nor recesses are present — i.e., holder 26 is smooth walled; feasible if primary sealer 22 bonds sufficiently strongly to the material of holder 26, dispensing with the need for interlocking features to assist in holding primary sealer 22 in place. Besides holding primary sealer 22 in position so that secondary sealers 24 are properly oriented, holder 26 also serves the purpose of supporting primary sealer 22 during the foaming process, to prevent sagging.

Figs. 7a, 7b, and 7c show in cross-sectional views various alternative arrangements of the preferred embodiment in which the sealing article is substantially planar in shape, with holder 26 and primary sealer 22 each also being substantially planar. (For simplicity, no secondary sealers 24 are shown in these figures.) In the arrangement of Fig. 7a, primary sealer 22 is disposed only on one side of holder 26, in a face-to-face relationship. In the arrangement of Fig. 7b, holder 26 is partially embedded in primary sealer 22. In Fig. 7c, holder 26 is fully embedded within primary sealer 22, excepting insert 27. These various alternative embodiments optionally may have through-holes 28 or openings 35. Illustratively, holder 26 may be between 2 and 4 mm in thickness (typically about 3 mm) and primary sealer 22 will be between 3 and 9 mm in thickness (typically about 6 mm). Holder 26 may be made of metal, or may be a molded part made of a material such as nylon or other engineering thermoplastic having the requisite chemical and mechanical stability to withstand the coating and baking operations.

Holder 26 may be a mechanical holder such as depicted in the various figures or equivalents thereof such as those disclosed in Cieslik et al., US 5,040,803 (1991); Soderberg, US 5,160,465 (1992); Soderberg, US 5,212,208 (1993); Takagi, US 5,213,391 (1993); Otto et al., US 5,506,025 (1996); Takabatake, US 5,631,027 (1997); Takabatake, US 5,642,914 (1997); Miller, US 5,678,826 (1997); Jones, US 5,725,272 (1998); Takabatake, US 5,806,915 (1998); and Raychem Corporation, WO 98/36944 (1998). Alternatively, non-mechanical holders may be used, for example, magnetic holders (Kobayashi, US 5,800,896 (1998)), suction holders (Miwa, US 5,649, 400); adhesive holders, and the like.

Those skilled in the art will appreciate that while acute corners commonly occur in pairs due to the mating to two pieces of stamped sheet metal and are so shown in the figures, the present invention is applicable to acute corner-containing cavities formed by other methods and having a greater or lesser number of acute corners. They will also appreciate, from an inspection of the figures, that acute corners may be located along one side of the cavity, as in the instance of Fig. 1, or may be along opposite sides of the cavity, such as in the instance of Fig. 5. The present invention is usable with all acute corners, without regard to their number or positioning relative to each other.

Suitable foamable materials for the primary sealer include those disclosed in Fried et al., US 4,166,890 (1979); Noda et al., US 4,203,815 (1980); Suzuki et al., US 5,091,435 (1992); Hanley et al., US 5,266,133 (1993); Hanley et al., US 5,373,027 (1994); Soderberg, US 5,385, 951 (1995); Tsuji et al., US 5,677,382 (1997); and co-pending, commonly assigned applications of Chang et al., Serial no. 08/925,422, filed Sep. 8, 1997, and Serial no. 09/028,122, filed Feb. 23, 1998.

Specifically, compositions for the primary sealer will be foamable polymer compositions having a foaming temperature appropriate to the temperature range of intended application, for example a foaming temperature within the range of temperatures to be encountered in bake ovens for vehicle bodies, and the like. Such compositions will contain a base polymer and a blowing agent to cause foaming of the polymer. They will typically also contain fillers, antioxidants, flame retardants, and/or other stabilizers such

as are conventional in polymeric articles, and may contain pigments, plasticizers, adhesion promoters, activators for the blowing agents, and the like.

The primary sealer may, and preferably will, contain a chemical crosslinking agent to strengthen the resulting foamed polymer, and may also contain a tackifier to maximize adhesion of the article to the cavity walls on foaming. The primary sealer may be crosslinked or uncrosslinked before foaming, the latter meaning that it is either totally free of crosslinking or has such a low degree of crosslinking that it substantially retains the foaming and adhesive characteristics of an uncrosslinked polymer. Desirably, the primary sealer becomes crosslinked on foaming, but it is within the scope of the invention that the primary sealer may be uncrosslinked (as defined immediately above) even after foaming.

Suitable base polymers include a wide range of polymers, typically chosen for a particular application so that the resulting article will foam at a convenient temperature for sealing of the cavity to be sealed and will be stable under intended use conditions.

Suitable base polymers include a wide range of polymers, typically chosen for a particular application so that the resulting article will foam at a convenient temperature for sealing of the cavity to be sealed and will be stable under intended use conditions. The melt flow rate, as measured by ASTM D-1238-95, of the base polymer (or mixture of polymers forming the base polymer) will desirably be from 0.5 to 10, preferably from 3 to 7, and in any event will desirably be chosen to give an appropriate degree of expansion of the sealing article during foaming.

Suitable polymers thus include olefinic polymers such as very low density polyethylene, low density polyethylene, medium density polyethylene, high density polyethylene, polyethylenes or ethylene copolymers prepared by metallocene polymerization (such as Exact [Exxon] and Engage [Dow]), ethylene copolymers such as ethylene-vinyl acetate copolymer, ethylene-methacrylic acid copolymer, ethylene-acrylic acid copolymer, ethylene-butyl acrylate copolymer, ionomers (such as Surlyn [duPont] and Iotek [Exxon]), ethylene terpolymers such as ethylene-vinyl acetate-methacrylic acid copolymer, elastomers such as ethylene-propylene rubber, EPDM, nitrile rubbers, butyl rubbers, chloroprene, chloropolyethylene, polyacrylate elastomers, chlorosulfonated polyethylene, thermoplastic elastomers, and fluoropolymers such as polyvinylidene fluoride, ethylene-

tetrafluoroethylene copolymer, fluorinated ethylene-propylene copolymer, poly(chlorotrifluoroethylene), ethylene-chlorotrifluoroethylene copolymer, etc., and mixtures of any two or more of the above.

The predetermined temperature range at which the primary sealer is foamed is typically between 115 and 250°C, such as found in bake ovens used in the automobile industry. More typically, the temperature range is between 150 and 180°C, with possible short excursions to temperatures above 180°C, for example as may occur when movement along an automobile assembly line is interrupted. Typical baking cycles are on the order of 30 min in duration.

Suitable fillers for the primary sealer include inorganic fillers such as zinc oxide, barium sulfate (Huberbrite), calcium carbonate, carbon black, magnesium hydroxide, alumina trihydrate, and the like; at a concentration up to about 40 parts per 100 parts of the base polymer.

The blowing agent is chosen so as to effect foaming and expansion of the primary sealer at an elevated temperature normally present during the manufacture of the product containing the cavity to be sealed; for example, at a temperature normally present during passage of an automobile body through a paint bake oven (typically 115°C to 250°C). Suitable blowing agents will include from 1 to 15 parts per 100 parts of base polymer of an azodicarbonamide or benzenesulfonyl hydrazide. Suitable azodicarbonamide blowing agents include Celogen® AZ 130 or 3990; and suitable modified azodicarbonamide agents include Celogen® 754 or 765, all from Uniroyal Chemical. Suitable benzenesulfonyl hydrazide blowing agents include p,p'-oxybis(benzenesulfonyl hydrazide), sold as Celogen® OT, and p-toluenesulfonyl hydrazide, sold as Celogen® TSH, both also from Uniroyal. The blowing agent may also be made up of a combination of agents depending on the degree of expansion desired for a particular application; and may also include a blowing agent activator such as diethylene glycol, urea, dinitrosopentamethylenetetramine (DNPT), and the like. Certain fillers, such as zinc oxide (Kadox), may also act as activators for the blowing agent. The amount of activator added will depend on the choice of blowing agent and the amount of expansion required.

Flame retardants may also be present, of such kinds and at such concentrations as will provide flame retardancy for the article. These may include halogenated flame retardants such as the polybrominated aromatics (e.g. decabromobiphenyl), and the like, for example in combination with inorganic materials such as antimony trioxide; or may include non-halogenated flame retardants, such as the magnesium hydroxide and alumina trihydrate previously mentioned as fillers.

The chemical crosslinking agent is preferably a free radical crosslinking agent compatible with the base polymer of the article. Preferred chemical crosslinking agents are peroxides, such as bis(t-butylperoxy)diisopropylbenzene, 1,1-di-t-butylperoxy-3,3,5-trimethylcyclohexane, 4,4-di-t-butylperoxy n-butyl valerate (Trigonox), dicumyl peroxide (Dicup), and the like. In most cases, the chemical crosslinking agent is provided at 1 to 5 parts per 100 parts of base polymer.

The blowing agent and the chemical crosslinking agent will be chosen so that the chemical crosslinking agent has an activation temperature approximately that of the blowing agent. For example, it may have an activation temperature slightly below that of the blowing agent, so that the foam maintains stability during expansion, but desirably the kinetics of the crosslinking and foaming reactions are such that the primary sealer expands and foams on heating, and adheres to the walls of the cavity, before the resulting foam is completely crosslinked by action of the chemical crosslinking agent. Desirably, the activation temperature of the blowing agent will be chosen so that the blowing agent is not easily accidentally activated (such as by mixing at a temperature above the optimal mixing temperature, during welding or other forming of a cavity in which the sealing article is emplaced, or during phosphating, painting or other coating treatments, or drying of such coatings) but is only activated when it encounters temperatures in which it is desired that the sealing article should foam, such as are present in bake ovens.

A tackifier, if present, will be chosen to enhance the tackiness of the primary sealer, in particular the periphery of the primary sealer which will come into contact with the cavity walls, on expansion but not such that it is tacky before expansion, since it is generally desirable that the outer surface of the primary sealer should be dry and non-tacky during initial placement of the article in the cavity. Desirably, to enhance the

adhesive qualities of the base polymer at the temperature of expansion, the tackifier will have a relatively low molecular weight, no significant crystallinity, a ring-and-ball softening point above at least 50°C (and preferably higher, near the softening point of the base polymer), and will be compatible with the base polymer and other polymers present. The tackifier may be present in up to 30 parts per 100 parts of base polymer. Suitable tackifiers include novolak resins, partially polymerized rosins, tall oil rosin esters, low molecular weight aromatic thermoplastic resins, Picco® and Piccotac® resins from Hercules Chemical, and the like.

Antioxidants, adhesion promoters, plasticizers, pigments, and the like may also be employed in conventional amounts.

Exemplary formulations include:

	Formulation, parts by weight			
Ingredient	**A**	**B**	**C**	**D**
Evatane 28-05 (EVA)		100		100
Elvax 470 (EVA)	100		100	
Irganox 1076 (antioxidant)	2	2	2	2
Kadox 911 (ZnO)	30	30		
Huberbrite 7 ($BaSO_4$)			30	30
Piccotac 95 (tackifier)				30
Varox 231 XL (chemical crosslinking agent)	2.5	1.5	2.5	1.5
Celogen TSH (blowing agent)		10		10
Celogen OT (blowing agent)	10		10	
Sartomer 350 (radiation crosslinking promoter)	5	5	5	5

Of these formulations, formulations A and C are particularly applicable to the manufacture of primary sealer 22, while formulations B and D are applicable to the manufacture of either primary sealer 22 or optional driver 36 (when used).

The composition may be prepared by methods conventional in the art of polymer blending, such as twin screw extruders, Banbury or Brabender type mixers, and sigma

blade mixers, with care being taken to ensure that the temperature of the blend does not rise to such an extent that the chemical crosslinking agent or blowing agent are activated. Typically, the base polymer, other polymers/tackifier (if present), and antioxidant are added first, and blended to homogeneity. The filler, adhesion promoter, pigments (if present) may be mixed with the base polymer, or may be added after the base polymer has been softened by mixing. These first mixing stages are not particularly temperature-sensitive. Once all ingredients other than the blowing and crosslinking agents have been added and fully blended, however, temperature control becomes important as these last agents are added. Accordingly, the mixer is cooled so that the temperature of the composition does not exceed about 95°C, and more preferably does not exceed about 80°C; the blowing agent(s), accelerator(s), crosslinking agents, and any plasticizers are added, and the resulting composition is subjected to high shear mixing under controlled temperature conditions until the composition is homogeneous. The composition may then be cooled, for example by processing through a two-roll mill with cooled rollers.

The resulting bulk composition may then be formed into the appropriate shape for the primary sealer by any appropriate means. For example, it may be extruded or rolled into sheets for cutting, extruded into rods of a desired cross-sectional configuration to be subsequently sectioned into the articles, molded into desired shapes, or pelletized for later molding or extrusion. Preferred methods of manufacture include injection molding and extrusion coating.

The particular composition used to make the primary sealer is not critical; and a person of ordinary skill in the art should have no difficulty, having regard to that skill and this disclosure, including the references cited here, in determining a suitable formulation to prepare a cavity sealing article of this invention or in optimizing such a composition for a particular application.

The secondary sealer may be a hot melt adhesive, such as a polyamide, an ethylene-vinyl acetate copolymer (EVA), an ethylene-vinyl acetate-acrylic acid (EVA-AA) terpolymer (for example, Elvax 4310 resin from du Pont), and the like. Alternatively, the secondary sealer may be a wax. The chemical identity of the secondary sealer is not critical. However, it should be sufficiently fluid in the melt to penetrate and seal the acute

corners. In one aspect, the secondary sealer preferably will have a viscosity lower than that of the primary sealer as the primary sealer is foaming. It is preferable that the secondary sealer have a melt flow rate of between 0.5 and 500, more preferably between 25 and 200, with the primary sealer with which the secondary sealer is paired comprising a base polymer having a lesser melt flow rate. Melt flow rate is measured according to ASTM D1238-95 (approved Nov. 19, 1995; published January 1996). The secondary sealer preferably bonds to both the primary sealer (a polymeric material) and the coated or uncoated cavity walls (typically a metal such as steel). The ability to bond to uncoated cavity walls is desirable because sometimes the coating process is not 100% efficient and may leave areas of the cavity walls bare.

The present invention may be used in combinations of plural seals (e.g., pairs) for improved acoustic baffling, as disclosed in copending, commonly assigned application of Chang et al., Serial no. 08/944,736, filed Oct. 6, 1997.

The foregoing detailed description of the invention includes passages that are chiefly or exclusively concerned with particular parts or aspects of the invention. It is to be understood that this is for clarity and convenience, that a particular feature may be relevant in more than just the passage in which it is disclosed, and that the disclosure herein includes all the appropriate combinations of information found in the different passages. Similarly, although the various figures and descriptions herein relate to specific embodiments of the invention, it is to be understood that where a specific feature is disclosed in the context of a particular figure or embodiment, such feature can also be used, to the extent appropriate, in the context of another figure or embodiment, in combination with another feature, or in the invention in general.

Further, while the present invention has been particularly described in terms of certain preferred embodiments, the invention is not limited to such preferred embodiments. Rather, the scope of the invention is defined by the appended claims.

All the patent documents cited in this specification, especially the US patents and patent applications, are incorporated herein by reference

CLAIMS

What is claimed is:

1. A sealing article for sealing a cavity whose cross-section includes an acute corner, comprising
   (a) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range;
   (b) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a viscosity within the predetermined temperature range lower than that of the primary sealer; and
   (c) a holder capable of holding the primary sealer in position within the cavity such that the secondary sealer is located opposite an acute corner of the cavity.

2. A sealing article according to claim 1, wherein the secondary sealer has a melt flow rate of between 0.5 and 500.

3. A sealing article according to claim 1, wherein the secondary sealer has a melt flow rate of between 25 and 200.

4. A sealing article according to claim 1 or 3, wherein the secondary sealer is disposed on an elevated surface portion of the sealer.

5. A sealing article according to claim 1 or 3, wherein the secondary sealer is pointed in shape, its tip generally aimed at the center of the acute corner in respect of which it is oppositely located.

6. A sealing article according to claim 1 or 3, wherein the predetermined temperature range is between 150 and 180°C.

7. A sealing article according to claim 1 or 3, wherein the sealing article is substantially planar in shape.

8. A sealing article according to claim 1 or 3, wherein the sealing article is substantially planar in shape, the primary sealer comprises uncrosslinked foamable polymer, and the sealing article further comprises a driver comprising crosslinked foamable polymer, the sealer being in intimate contact with the driver and surrounding the driver in the plane of the sealing article.

9. A sealing article according to claim 1 or 3, wherein the sealing article is substantially planar in shape and the primary sealer is disposed perimetrically around the edge of the holder.

10. A sealing article according to claim 1 or 3, wherein the secondary sealer perimetrically surrounds the primary sealer.

11. A sealing article according to claim 1 or 3, wherein the secondary sealer is a hot melt adhesive or a wax.

12. A method of sealing a cavity whose cross-section includes an acute corner, comprising the steps of

(a) providing a sealing article comprising

(i) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range;

(ii) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a viscosity within the predetermined temperature range lower than that of the primary sealer; and

(iii) a holder;

(b) placing the cavity sealing article within a cavity whose cross-section includes an acute corner, the holder holding the primary sealer in position

such that the secondary sealer is located opposite an acute corner of the cavity; and

(c) heating the primary sealer to within the predetermined temperature range to cause the primary sealer to foam and the secondary sealer to flow, the foaming of the primary sealer driving the secondary sealer into the acute corner opposite which the secondary sealer is located.

13. A method according to claim 12, wherein the cavity is a channel automobile body.

14. A method according to claim 12, wherein the predetermined temperature range is between 150 and 180°C.

15. A method according to claim 12, wherein the sealing article is placed within the cavity such that the primary sealer is spaced apart from the walls of the cavity.

16. A method according to claim 12, wherein the acute corners are pinch flanges.

17. A method according to claim 12, wherein the secondary sealer has a melt flow rate within the predetermined temperature range of between 25 and 200.

18. A method according to claim 12, wherein the secondary sealer is a hot melt adhesive or a wax.

19. In combination,

(a) a cavity whose cross-section includes an acute corner and

(b) within the cavity, a sealing article comprising

(i) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range;

(b) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a viscosity within the predetermined temperature range lower than that of the primary sealer; and

(c) a holder which holds the primary sealer in position such that the secondary sealer is located opposite an acute corner of the cavity.

20. A combination according to claim 19, wherein the cavity is a channel in an automobile body.

21. A combination according to claim 19, wherein the cavity is formed by two sheet metal pieces joined together.

22. A combination according to claim 19, wherein the secondary sealer has a melt flow rate within the predetermined temperature range of between 25 and 200.

23. A sealing article for sealing a cavity whose cross-section includes an acute corner, comprising

(a) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range, the foamable material comprising a base polymer having a melt flow rate of between 0.5 and 10;

(b) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a melt flow rate of between 25 and 200; and

(c) a holder capable of holding the primary sealer in position within the cavity such that the secondary sealer is located opposite an acute corner of the cavity.

24. A sealing article according to claim 23, wherein the base polymer of the primary sealer has a melt flow rate of between 3 and 7.

25. A method of sealing a cavity whose cross-section includes an acute corner, comprising the steps of

(a) providing a sealing article comprising

(i) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range, the foamable material comprising a base polymer having a melt flow rate of between 0.5 and 10;

(ii) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a melt flow rate of between 25 and 200; and

(iii) a holder;

(b) placing the cavity sealing article within a cavity whose cross-section includes an acute corner, the holder holding the primary sealer in position such that the secondary sealer is located opposite an acute corner of the cavity; and

(c) heating the primary sealer to within the predetermined temperature range to cause the primary sealer to foam and the secondary sealer to flow, the foaming of the primary sealer driving the secondary sealer into the acute corner opposite which the secondary sealer is located.

26. In combination

(a) a cavity whose cross-section includes an acute corner and

(b) within the cavity, a sealing article comprising

(i) a primary sealer comprising a foamable material which foams upon heating to within a predetermined temperature range, the foamable material comprising a base polymer having a melt flow rate of between 0.5 and 10;

(ii) a secondary sealer disposed on a surface of the primary sealer, the secondary sealer having a melt flow rate of between 25 and 200; and

(iii) a holder which holds the primary sealer in position such that the secondary sealer is located opposite an acute corner of the cavity.

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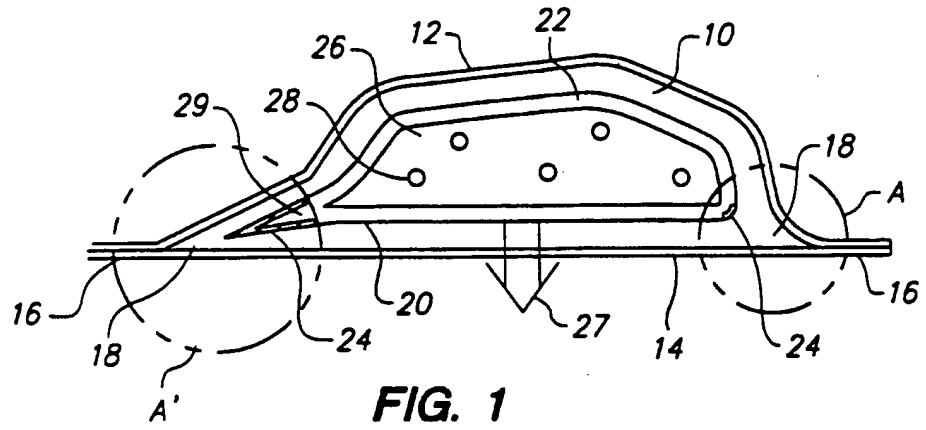

FIG. 1

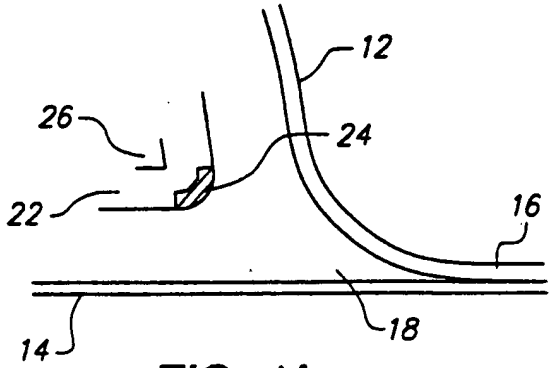

FIG. 1A

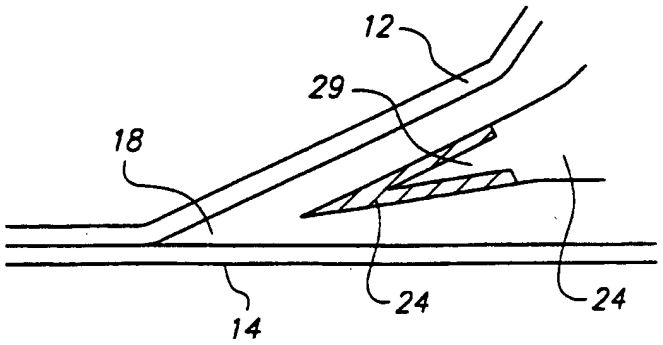

FIG. 1B

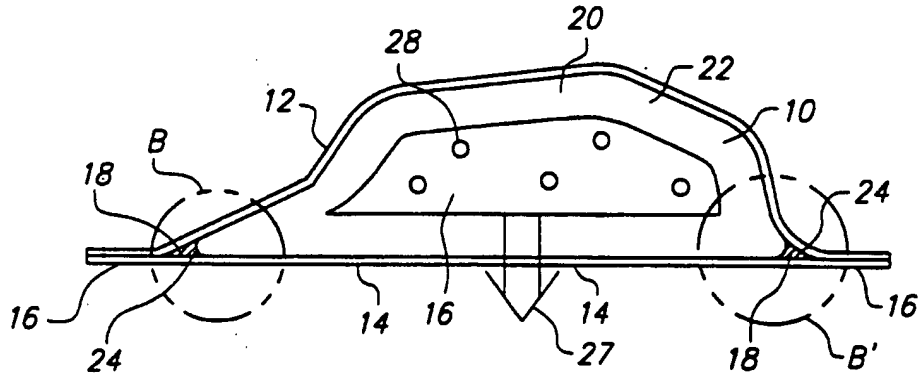

FIG. 2

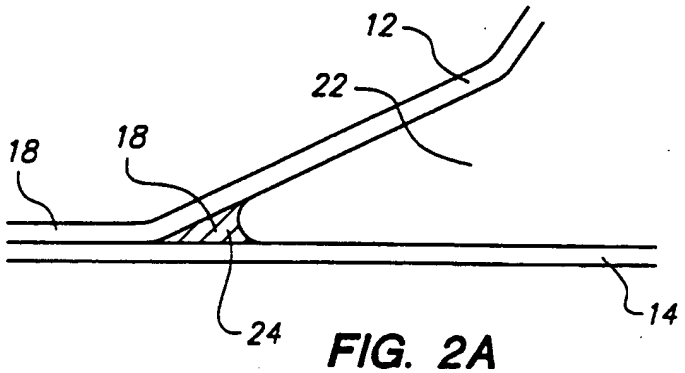

FIG. 2A

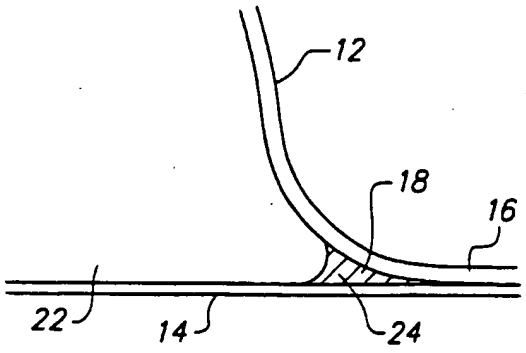

FIG. 2B

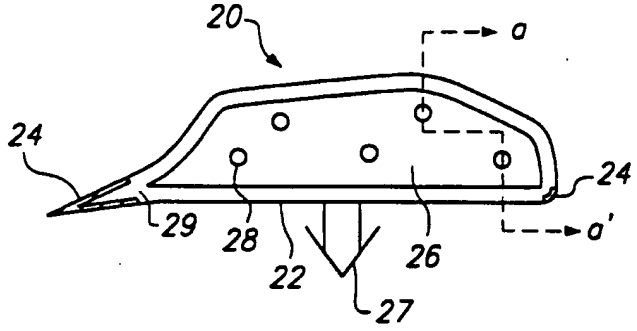

FIG. 3

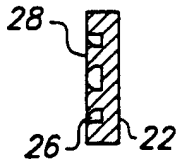

FIG. 3A

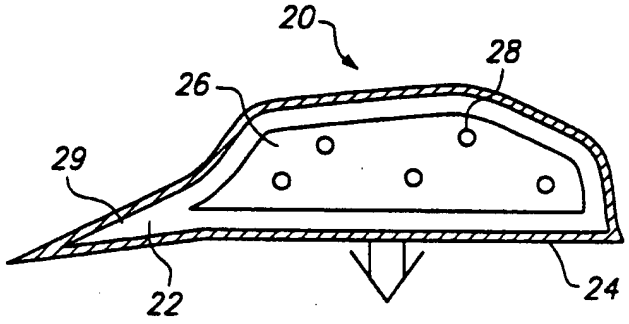

FIG. 3B

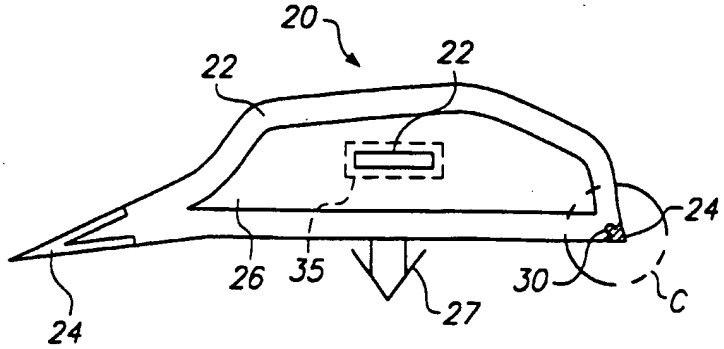

FIG. 4

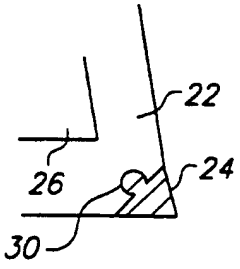

FIG. 4A

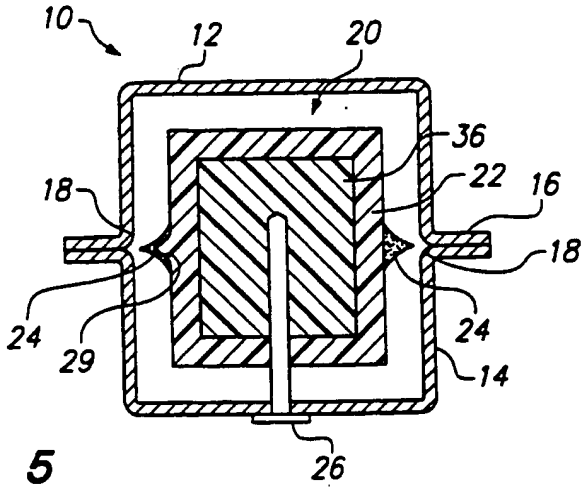

FIG. 5

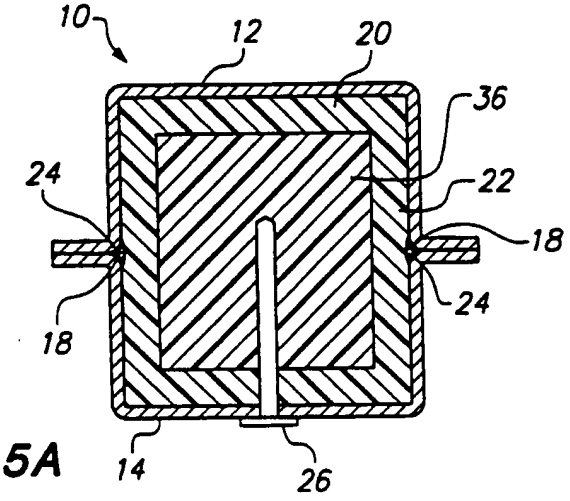

FIG. 5A

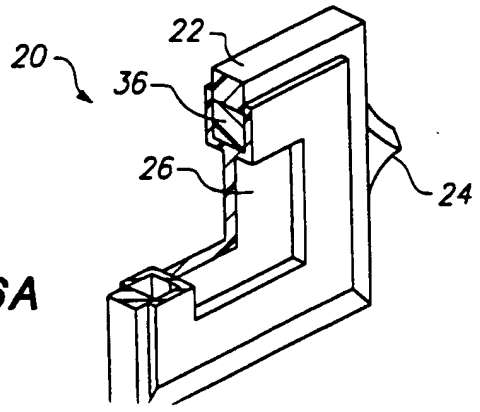

FIG. 6A

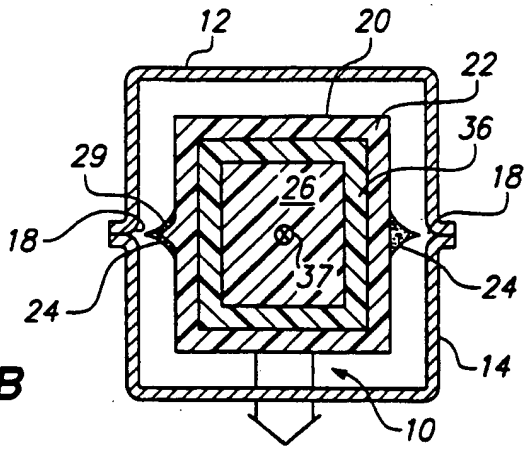

FIG. 6B

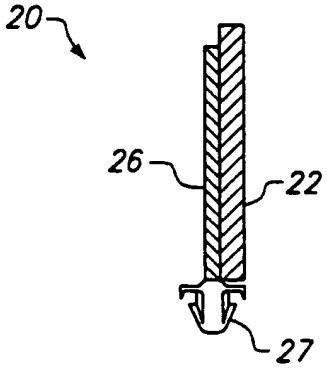

FIG. 7A

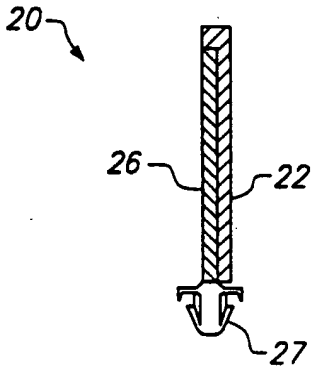

FIG. 7B

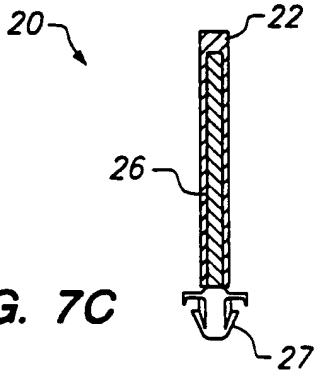

FIG. 7C

INTERNATIONAL SEARCH REPORT

Int ational Application No
PCT/US 00/03079

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B62D29/00 B60R13/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B62D B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO 98 36944 A (RAYCHEM CORP) 27 August 1998 (1998-08-27) figure 1 page 4, line 7 -page 5, line 20 page 8, line 3 -page 8, line 30 page 21, line 6 -page 24, line 6 page 31, line 19 -page 32, line 24 page 35, line 6 -page 36, line 19 ---	1,2,6-9, 12-15, 19-21,23
P,A	WO 00 03894 A (CASCADE ENG INC) 27 January 2000 (2000-01-27) page 3, line 10 -page 4, line 22 figures 1-3 ---	1,6-9, 12-15, 19-21,23

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 June 2000	26/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Deraymaeker, D

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Int. .tional Application No
PCT/US 00/03079

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO 99 54170 A (UT AUTOMOTIVE DEARBORN INC) 28 October 1999 (1999-10-28) figure 2 page 3, line 4 -page 4, line 8; claims 1,14,15 -----	1,7-9, 12,13, 15,19, 20,23

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. .tional Application No
PCT/US 00/03079

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9836944 A	27-08-1998	US 5979902 A	09-11-1999
		AU 6176898 A	09-09-1998
		EP 0961715 A	08-12-1999
		US 5931474 A	03-08-1999
WO 0003894 A	27-01-2000	NONE	
WO 9954170 A	28-10-1999	US 6062624 A	16-05-2000